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A Laboratory Lesson in Variation

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It is commonly agreed that the essence of good science teaching consists in 'exposing' the student to objective realities, and in helping him to draw his own deductions and inductions from what he observes. With respect to evolution, however, is it not a fact that this topic is chiefly presented and studied, at least in elementary courses, through the medium of books? That many learn to talk glibly regarding the 'evidences' of evolution who have no real first hand acquaintance with the underlying facts? A comment of the late John M. Coulter a few years ago is pertinent in this connection. (Science 63: May 1926). "The meaning of evolution is probably more misunderstood than any doctrine of science. The reason is that it has been discussed very freely by those who are not informed, and in this way much misinformation has been propagated."

It is the purpose of this article to offer an outline of a possible laboratory lesson through which the most fundamental factor of evolution may be presented objectively. The lesson, which has been used a number of years in fourth year high school biology, is based on the following premise: While all the data derived from the study of the facts of morphological resemblances among related forms, of geographic distribution, of geologic succession of types, of embryologic and ontogenetic development, of plant breeding, etc., are valuable and important as circumstantial evidence, any final understanding of the basic problem of evolution must be sought in a study of *variation* as a *process*.

If the pupil can be shown that occasionally in reproduction a given parent or parents produce offspring which differ from the parent type, and not merely by the re-shuffling of characteristics already possessed by collateral forms, he has been brought face to face with the elemental fact upon which any real understanding of evolution must be based. His clear perception of this primary fact will enable him to analyze and ap-

Photograph from the Brooklyn Garden

FIGURE 1. Vegetative reproduction in Nephrolepis. In this case, the three bud plants are all like the parent. In variation one or more would be different. Such a variation would have to take place along the slender connecting stem.

preciate the meaning of the whole problem. He will be looking at the problem sharply and clearly, not merely vaguely and in the large. The methods of the proposed lesson are outlined in detail as follows:

Specific Problem: What is Meant by Variation?

Variation is one of the numerous words which have a number of different connotations. It should be clear at the start that the looser, broader meanings are definitely excluded; that the word is not used here in the common interpretation as referring to the range of differences among a group of sibs, or between the individuals of a larger species population. The meaning can be finally narrowed and sharply delimited to the desired applicaiton, as indicated in the preceding paragraph, by raising the question: Will evolution take place if offspring always repeat the exact characteristics of their parents? In other words, why must variation occur as a process in reproduction if new forms are to occur?

Is there any evidence of such variation? Is there any material which can be introduced into the school laboratory to help in answering the questions raised? In this connection, the Boston fern series, a number of which are common in the florist trade, furnish excellent material for class study. They are relatively common, and the material is not difficult to obtain. The range of variation between the different varieties is wide, the differences well-marked, and the material is large enough so that the differences can be easily discerned. The total number of scores of types have had a recent history. The method of reproduction is entirely vegetative, thus eliminating any complication of the possible influence through hybridization. Incidentally, it may be noted that the Brooklyn Botanic Garden has served for nearly twenty years as a source of sets of specimens of these ferns, both series of leaves and of growing plants for experimental and teaching use. So far as material is available, the writer will be glad to furnish further material of this sort.

The mode by which variation must have taken place in these fern types can be easily pointed out, and is illustrated in figure 1. This shows a parent plant of the wild sword fern (*Nephrolepis exaltata*) from which the Boston fern was derived, in association with three offspring which have arisen along a lateral stolon. Such stolons are common in florists' or house specimens of Boston fern varieties, and the method of vegetative propagation along stolons can usually be demonstrated by digging up a little surface dirt around a well-established pot plant, or a demonstration, like that illustrated, can be prepared if provision is made a few weeks in advance of need.

While in general, as in the case illustrated, the offspring are practically identical with their parent, it has occurred a number of times, in the florists' cultivation of millions of Boston fern plants, that an occasional bud plant has arisen which, while still

FIGURE 2. A leaf of the Boston fern (left) with leaves of the seven primary sports. In each case, the original mutation took place in vegetative reproduction (See Fig. 1). The seven varieties are arranged as follows: Piersoni; Anna Foster; Scotti; Giatrasi; Harrisi; Rossevelti; Gretnai.

in physical connection with its parent plant, has shown distinct differences from that parent. In figure 2, there is shown the leaves of a typical Boston fern together with seven such departures or variations. Beginning with the first new plant, each of these variations thereafter reproduced only its own type, maintaining the difference from the parent Boston fern, and thus representing that kind of variation that is inherited, or *mutation.*

This does not establish just what the process of variation is; it merely makes obvious the fact of its occurrence, and it is evident also, that whatever happened must have taken place somewhere along the stolon or reproductive branch from which the different buds arose. Further inquiry and speculation as to the exact nature of variation must wait until some later lessons in which the cell basis of reproduction and heredity, and of possible gene modification can be examined.

The third figure, showing the representative pinnae of the same leaves shown in figure 2, makes clearer just what types of differences have occurred as a result of the variation process in the Boston fern. When it is realized that these differences parallel to some extent the characteristics which distinguish recognized fern species, added emphasis is given to their possible significance. When, in addition, consideration is given to the extremes of modification developed through secondary and further variation in this same group of ferns, resulting in the scores and scores of well distinguished varieties, a new understanding should attach both to the meaning of variation as a process and to its underlying significance in any consideration of the whole process of evolution. Space does not permit any other illustration of the wide variety of size and form represented in the whole series of Boston fern mutations which has been presented elsewhere. However, a chart showing the genealogy of a large number of the named varieties which had been introduced up to about ten years ago is reproduced, taken from another source. As it happens, the wave of interest on the part of florists in introducing new types of these ferns has practically ceased, owing to a variety of factors.

Besides the varieties which have been introduced commercially with names, scores of others have been noted by florists which, while distinctive enough, did not appear to offer commercial possibilities and so did not attain to the dignity of being named. Dozens of new forms have appeared in the collections at the Brooklyn Botanic Garden during the years of experimental culture, most of which have been described in various reports, although without special names.

Some reference to the specific varieties illustrated and their most obvious distinguishing characteristics will be appropriate. Four different kinds of variation are represented among these primary sports of the Boston fern: (1) increase in division, from once to twice pinnate; (2) dwarfing; (3) increase in ruffling; and (4) cresting.

The second and third leaves and corresponding pinnae represent increased leaf division. The third leaf is from the "Anna Foster" variety, the earliest of all the Boston fern sports, but it was soon supplanted in the esteem of the florists by the "Pierson" fern, shown in the second leaf and pinnae, due to the more desirable horticultural characteristics of the latter. From this form alone, scores of secondary tertiary, and higher degree sports have developed, resulting in various degrees of leaf division,—as much as five pinnate,—and other modifications.

FIGURE 3. Pinnae of the Boston fern and of the seven primary mutations, arranged as in Figure 2. It is a simple laboratory exercise to have pupils make outline drawings of a Boston fern pinna with one or more of the other types for comparison.

The fourth and fifth leaves and pinnae represent dwarf types, respectively "Scott's" fern, of Brooklyn origin, and the "Giatras" fern, Hoboken Greek. In addition to their smaller size, each offers other differences in outline, marginal characters, and configuration of the pinnae, as well as in habit of growth.

The sixth and seventh leaves and pinnae present intensification of the ruffling or waviness of the pinnae, horticulturally known as *crisping*. The larger leaf (6) is called the "Harris" fern, after its introducer, a Philadelphia grower. The other, the "Roosevelt" fern, was introduced by an Ohio florist.

Lastly, there is a *crested* or "fishtail" type of variation, which occurs not infrequently in wild native species. In the Boston

Genealogy of the American Varieties of Boston Fern

Magnifica

Clarki Smithi—Craigi

Verona——

Gracillima

Trailing

Goodi Emerald

Fleece

Barrowsi Whitmani Whitmani

Milleri—— Compacta

Elegantissima—Galvestoni Elmsfordi

Robusta—

Millsi

Piersoni Spendida—Baeri

Superior

Fertilis—— Elegantissima- Eleg: Compacta

Compacta Cristata

Wanamaker —

Dwarf Boston——

Superbissima—Muscosa

Childsi—

Viridissima—— Pershing –

3-Pinnate— Schuberti

Anna Foster Sport

Exaltata— —?— Amperpohli

Boston Fern

Harrisi—W. K. Harris

Dwarf Sport

Teddy Jr. Randolph—Victory

Roosvelti Roosevelti

Improved Wilsoni

Wagneri

Scotti Falcata

Scholzeli—3-Pinnate Scholzeli

?Gretnai

New Jersey

Giatrasi Queen Sophie

New York——

King Constantine

fern series this variety first appeared in Louisiana, and takes its name from the town of its origin, "Gretna."

In using this material in the laboratory, pupils have usually been asked to make diagrammatic outline sketches of the Boston fern type of pinna with one or two of the mutative types, to emphasize the visible differences. In their notes, emphasis was placed on the inherited character of such variations and the fact that this constituted them as mutations. At the same time, by way of comparison, they were usually given the chance to examine some type of spotted bean, such as the "yellow eye," which had a large pigmented area on a white background. These were used to illustrate the "fluctuating" type of variation, as offering differences grading by imperceptible steps into the parent form and not repeated in inheritance, anyone of which might give rise in reproduction to a complete series of color spot gradations.

That evolution if has taken place, must have occurred by means of inherited variations will be accepted as axiomatic, regardless of whether one believes all variations proceed from the stimulation of hybridization or through spontaneous variation of some unexplained cause. That the student who has examined material of the kinds presented here will thereafter always carry a clearer conception of what is meant by variation, and a better understanding of the relation of this process to evolution seems, to the writer, to be a justifiable conclusion.

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